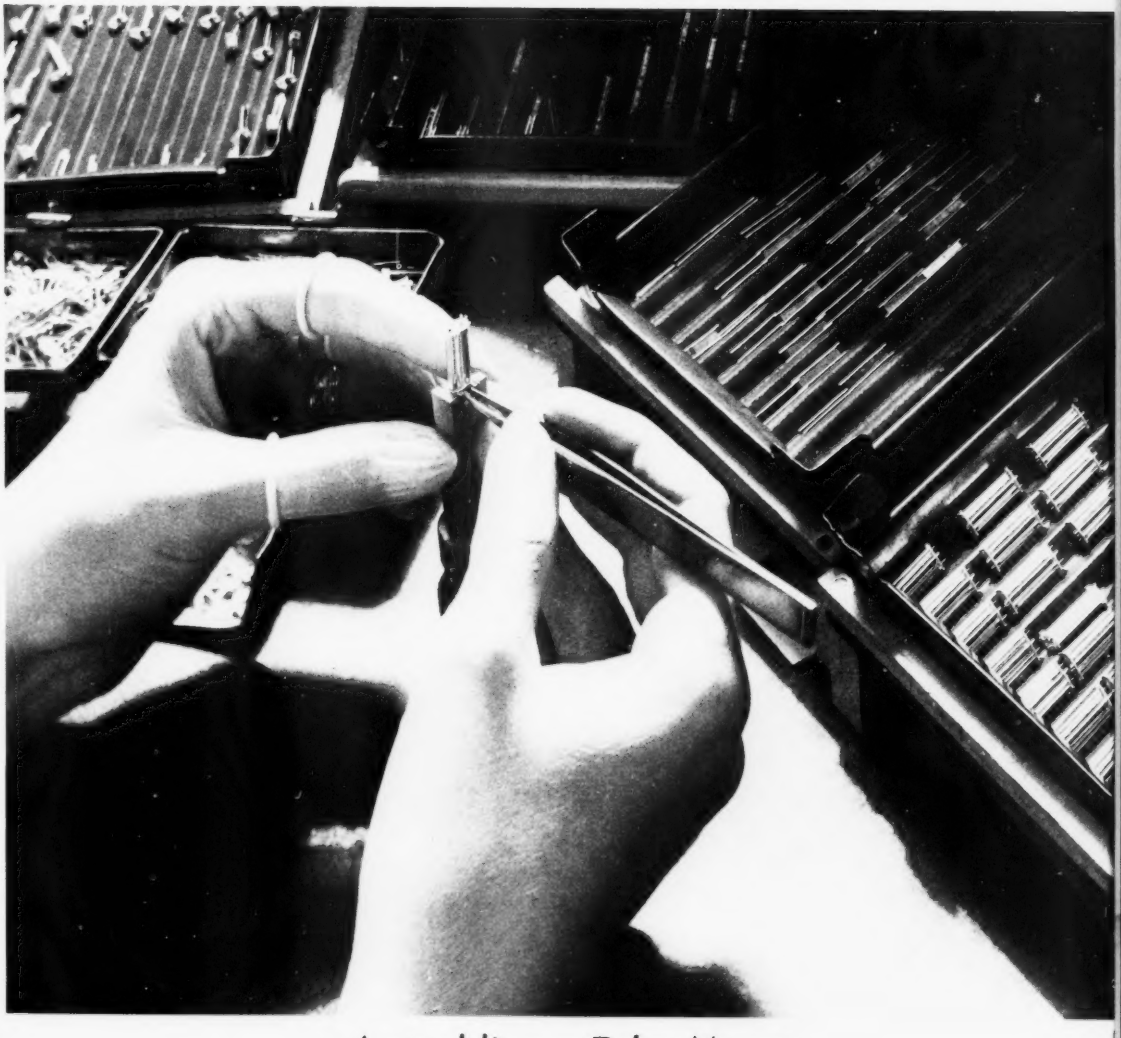
RAYTHEON

ELECTRONIC PROGRESS

JANUARY
FEBRUARY 1958



Assembling a Tube Mount

In this issue: **VACUUM TUBE PRODUCTION**

ELECTRONIC PROGRESS

Volume II January-February 1958 Number 4

RAYTHEON

Ivan A. Getting ..... *Executive Editor*

James Sterling ..... *Managing Editor*

Marcia Keilson ..... *Editor*

Elmer J. Reese ..... *Art Editor*

ASSOCIATE EDITORS

Stanley D. Crane
Santa Barbara Laboratory

Richard P. Curtis
Commercial Equipment Division

Ronald D. Eames
Government Equipment Division

Frank Finnegan
Semiconductor Division

Alvin S. Luftman
Microwave and Power Tube Division

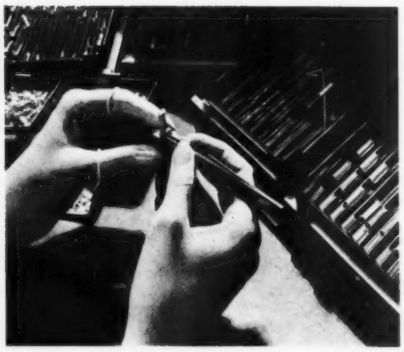
Laurence G. Rubin
Research Division

Michael A. Walker
Missile Systems Division

Robert D. Wilson
Receiving Tube and Semiconductor Operations

Copyright 1958
Raytheon Manufacturing Company
Waltham 54, Mass.

THE COVER



The photograph on the cover showing a stage in the mount assembly of a subminiature vacuum tube stresses the infinite detail involved in this work, as well as the minuteness and delicacy of the parts that must be handled. Where variations of the magnitude of a human hair can mean the difference between a tube which is acceptable and one which is not, it has been found that patience and care rank in importance with skill and dexterity as prerequisites for an assembly worker.

Committees

	CHAIRMAN		CHAIRMAN
Analog Computer	*H. Miller*	Plastics	*R. Mondano*
Ceramics	*S. Blum*	Semiconductor Devices Circuit	*J. Mofenson*
Digital Computer	*H. Miller*	Ultrasonic	*T. Hueter*
Ferrite	*L. Davis, Jr.*	Welding	*R. Allaire*
Magnetic Amplifiers	*D. McMurtrie*		

Calendar

ENGINEERING SEMINARS

Tentative Schedule

Raytheon Missiles—Sparrow III T. P. Cutler, Missile Systems Div.	Jan.	8	CONFIDENTIAL
After the Breadboard—What? E. D. Graham, Vice President, Engineering Services	Jan.	15	UNCLASSIFIED
Raytheon in the Field of Communications P. J. Pontecorvo, Government Equipment Div.	Jan.	22	UNCLASSIFIED
Generation and Applications of Microwave Power C. L. Calosi, Vice President and E. J. Shelton, Microwave and Power Tube	Jan.	29	UNCLASSIFIED
Relations between Manufacturing Techniques and Performances of Transistors G. Freedman, Transistor Development Laboratory	Feb.	5	UNCLASSIFIED
The Money Problem H. S. Geneen, Executive Vice President	Feb.	12	UNCLASSIFIED BUT COMPANY PRIVATE
Countermeasures and Anti-countermeasures H. K. Hudson, Government Equipment Div.	Feb.	19	CONFIDENTIAL
ARSR, Air Route Surveillance Radar B. I. McCaffrey, Government Equipment Div.	Feb.	26	UNCLASSIFIED

Contents

Ultrasonics ..... *T. F. Hueter* 1

Vacuum Tube Production ..... *F. Barry* 5

Ultrasonic Soldering of Aluminum ..... *C. Campbell* 8

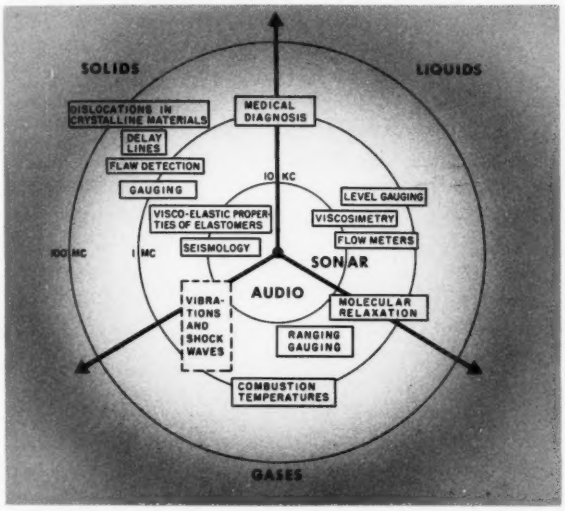
Patents — Their Origin, Nature and Subject Matter ..... *B. Lemlein* 10

Papers and Publications 13

ULTRASONICS

T. F. Hueter
Wayland Laboratory

Figure 1. Analytical uses of sound



The phenomenon of acoustic vibration can be utilized in many ways other than those that come immediately to mind when we think of sounds in everyday life. Sound waves can penetrate many solids and liquids more readily than X-rays or other forms of electromagnetic energy. Thus sound can expose a tiny crack many feet deep in metal, where detection by any other means might be commercially impracticable, if not impossible. Ultrasonic pulse techniques similar to those used for submarine detection, fish finding and depth sounding, are now being used in medicine for the early diagnosis of abnormal tissue growths. By acoustic techniques we can measure the elastic constants of solid materials, and residual stresses or structural changes as in work hardening, age precipitation and annealing. The molecular arrangements within many organic liquids can be inferred from measurements of sound velocity or absorption. The rates of energy transfer among gas molecules and the chemical affinity of gaseous mixtures can also be determined by using sound waves.

In another class of applications, large amounts of acoustic power can be employed to do useful work. Vibrational energy is used to drill rock, to machine complicated profiles in one single operation, and to engrave all kinds of jewelry. As a potent microagitator, sound will facilitate the emulsification of liquid mixtures and will speed up such processes as homogenization or dispersion. Acting on aerosols, such as powders, dust, and smoke, sound can speed up agglomeration, collection or drying of particles.

The frequency range that is best suited for any particular one of the various tasks listed above is determined by the special requirements and limitations of that task. As an example, Figure 1 presents some of the more common analytical uses of sound waves, grouped according to the three general classes of propagation media. We note that the audio field which is ordinarily identified with endeavors in acoustics occupies only a rather small sector in the whole spectrum of analytical applications of sound. Obviously, the relation of the frequency used in most industrial applications of ultrasound to the range of audibility for man's ear is quite irrelevant. Therefore, the very term "Ultrasonics" which implies sound waves above the range of the ear, tends to impose an arbitrary limit on a field which potentially ranges from a few cycles per second to several hundred megacycles per second. Indeed, particularly in sonic processing, low frequency methods are often potentially superior to truly "ultrasonic" methods.

Of the two classes of applications previously indicated, analysis and processing, let us first consider some of the techniques that are used in sonic analysis. For the measurement of sound velocity or wavelength there are two methods of choice, standing-wave or pulse techniques. In standing-wave techniques, the periodicity in space of one of the acoustic field variables—pressure, density or particle velocity—is determined. Typical devices that are widely used are the acoustic interferometer and the impedance tube. In pulse techniques, the time required by a short wave

Item	Pure longitudinal (bulk waves)	Pure transverse (shear waves)	Extensional (rod waves)	Flexural (bending waves)	Surface (Rayleigh waves)
Boundary requirements	Infinite	Infinite	Finite	Finite	Infinite
Dimensions of sample	$d \gg \lambda$	$d \gg \lambda$	$d \leq \lambda$	$d < \lambda$	$d \gg \lambda$
Modulus of elasticity	$\lambda' + 2\mu$	μ	Y	Dependent on λ and d	Dependent on μ and σ
Sound velocity	$\sqrt{(\lambda' + 2\mu)/\rho}$ $\sqrt{\frac{Y}{\rho}\frac{1-\sigma}{(1+\sigma)(1-2\sigma)}}$	$\sqrt{\mu/\rho}$ $\sqrt{\frac{Y}{\rho}\frac{1}{2(1+\sigma)}}$	$\sqrt{Y/\rho}$ $\sqrt{\frac{\mu}{\rho}\frac{3\lambda' + 2\mu}{\lambda' + \mu}}$	Rod of radius r: $\sqrt{\omega r/2} \times \sqrt[4]{Y/\rho}$ Plate of thickness d: $\sqrt{\omega d/2} \times \sqrt[4]{\frac{Y}{\rho}\frac{1}{3(1-\sigma^2)}}$	$\frac{0.87 + 1.12\sigma}{1+\sigma}\sqrt{\mu/\rho}$
Wave-type conversion at boundary	Partly to shear wave	Partly to bulk wave	To Rayleigh wave as $\lambda \ll d$	To Rayleigh wave as $\lambda \ll d$	

Table I. Types of waves in isotropic solids

train to travel a given distance is measured. Standing-wave techniques are usually more suitable in the kilocycle range of frequencies, whereas pulse techniques are indicated for the megacycle range.

At this point we must note that, whereas only one type of wave—namely, longitudinal—exists in gases, additional forms of wave propagation are possible as the rigidity and structure of matter change. For example, liquids of high viscosity may support shear waves in addition to longitudinal waves. In isotropic solids we must distinguish between five different types of waves (Table 1). Finally, anisotropy will lead to a dependance of sound velocity on the direction of propagation, with regard to the crystal axes.

If the variation of pressure and the density in a sound wave are in phase, the wave propagates without loss of energy. However, once the period of the sound vibration is comparable with the time constant of a molecular or structural relaxation process, the density will lag behind the pressure. The loop area of the resulting pressure-density diagram then represents the energy that is lost per cycle. Another source of losses is multiple reflection or scattering that is caused, for example, by grain boundaries in polycrystalline materials. In principle, such losses may be determined in four different ways, as illustrated in Figure 2. They are (i) the time decay of forced vibrations in a standing-wave system, (ii) the decrease in amplitude with distance in progressive waves, (iii) the bandwidth of a harmonic mode of a resonating system, and (iv) the standing-wave ratio in an impedance tube. Many technical materials have been analyzed by these methods, and useful correlations have been established between their loss behavior and other physical properties.

We now come to the other application of sonics—namely, the processing of materials. It has been found that intense vibrations affect colloidal distributions, equalize electrolytic concentrations, and speed up aging processes. Also, by absorption in a lossy medium, intense vibrations may produce local heating effects as, for example, in the use of ultrasonics in medical therapy. In general, one may distinguish between two types of action—effects that are localized at interfaces between different kinds of media or between constituents of the same medium, and volume effects.

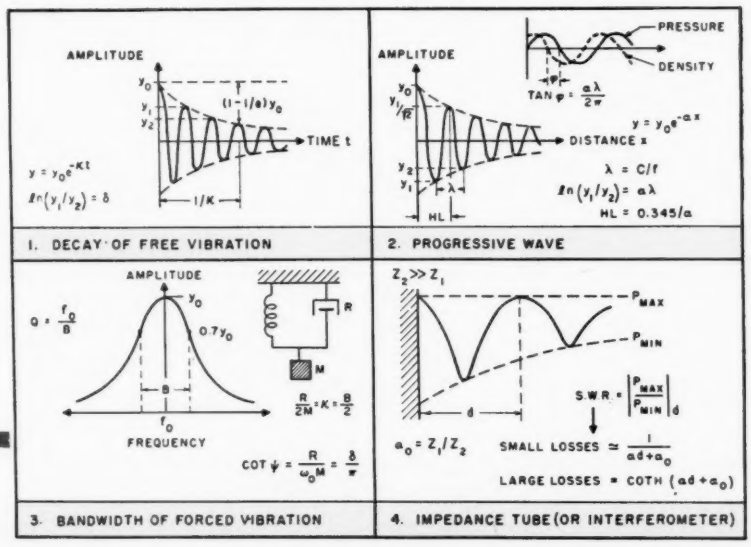


Figure 2. Basic techniques for attenuation measurements

Interface effects play a predominant role in power sonics and lead to a number of unusual phenomena. They are produced more readily than volume effects. For example, small bubbles or particles suspended in a liquid are subjected to drag forces in a sound field; similar forces come into play if a sound field interacts with an aerosol. This, then, is the physical basis for such processes as sonic stirring, degassing, and coagulation.

A particularly powerful phenomenon is cavitation. This is the breakdown of the cohesion of a liquid that is exposed to high tensile forces as the sound wave passes through it. Such breakdown usually occurs at the weakest points within the liquid. Tiny bubbles, dust particles, and particularly interfaces where poor wetting conditions exist, facilitate the onset of cavitation. As the term cavitation implies, cavities are formed in a liquid during the negative pressure phase of the sound wave; during the subsequent positive pressure phase, these cavities collapse, producing pressure peaks that may reach several hundreds of atmospheres. Under the influence of cavitation, steel

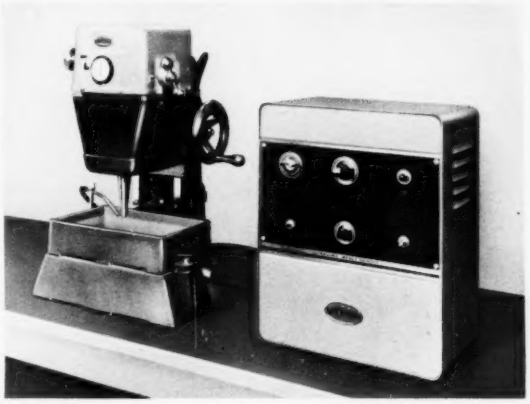


Figure 3. Ultrasonic Impact Grinder

surfaces may be pitted, oxide layers removed, bacteria disintegrated, or high polymers depolymerized. One particularly successful application of surface cavitation is exemplified by the Raytheon Impact Grinder (Figure 3); another is in the soldering of aluminum.

The frequency range covered by the above mentioned applications is extremely wide, both for the analytical uses and for the processing uses of sound energy. Their realization therefore entails widely different acoustic engineering practices, which is a characteristic feature—and sometimes a difficulty—of industrial ultrasonics. Table 2 lists a number of processes in which sound energy at high power levels can bring about a major improvement over existing methods. Of the four processes listed, ultrasonic degreasing and cleaning has already become an established industrial technique, and reliable equipment of 0.5 to 3 KW

PROCESS	DECREASING, CLEANING AND ELECTROPLATING	HOMOGENIZATION AND EMULSIFICATION	PROMOTION OF CHEMICAL REACTIONS	REFINEMENT OF METAL MELTS
Optimum frequency range	20—400 kc/sec	0.2—100 kc/sec	0.2—20 kc/sec	0.2—200 kc/sec
Type of substrate	Solid surfaces immersed in detergent liquid or electrolyte	Colloidal system	Substances responding to free radicals	Solidifying melts
Physical mechanism	Acoustic shearing and cavitation shock	Cavitation-induced turbulent mixing	Formation of hydroxyl groups by cavitation	Redistribution of nucleatron center
Types of transducers	Magnetostrictive (ferro-electric)	Hydrodynamic Electromagnetic (Magnetostrictive)	Aero-mechanical Hydrodynamic Electromagnetic	Electrodynamic (Magnetostrictive

Table II. Processing uses of high power sources

power rating whose manufacture, sales and maintenance have proved to be economical is commercially available. The other three processes have not yet been fully scaled up from laboratory type equipment to the magnitudes in power level and processing capacity that are necessary for industrial purposes. They constitute today's challenge to transducer designers and sonic system engineers.

The success of these processing methods depends largely on the availability of transducer mechanisms that are capable of generating sonic power economically, both in sufficient amounts and in a way compatible with the flow of industrial production. If the materials to be treated are encountered in small or medium-size batches, conventional transducers of the magnetostrictive or piezoelectric type may handle the job. (For example, in the brewery industry such units have been installed for the extraction of vegetable bitters from the hop.) They become impractical, however, for either very large batches or high rates of liquid flow. For large batches the recently developed hydrodynamic valve oscillators appear promising. Figure 4 shows such a hydrodynamic transducer coupled to a treatment tank, according to the method of J. V. Bouyoucos. Direct-current flow energy is provided by a pump. Fluctuations of pressure at the left side of the diaphragm produce a flow modulation owing to changes in the gap area of the valve. The resulting pressure changes at the valve end of the feedback loop are transmitted through the loop back to the diaphragm. Stable oscillations build up at a frequency for which the half-wavelength equals the loop length. Sound energy is extracted from the loop by a transmission-line section terminated by a dome-shaped acoustical window.

If cavitation-type treatment of a continuous liquid flow is desired rather than batch irradiation, the vibratory members of the transducer must become an integral part of the flow system. One approach to this task is the Sonic Oscillator developed by Submarine Signal

Item	Pure longitudinal (bulk waves)	Pure transverse (shear waves)	Extensional (rod waves)	Flexural (bending waves)	Surface (Rayleigh waves)
Boundary requirements	Infinite	Infinite	Finite	Finite	Infinite
Dimensions of sample	$d \gg \lambda$	$d \gg \lambda$	$d \leq \lambda$	$d < \lambda$	$d \gg \lambda$
Modulus of elasticity	$\lambda' + 2\mu$	μ	Y	Dependent on λ and d	Dependent on μ and σ
Sound velocity	$\sqrt{(\lambda' + 2\mu)/\rho}$	$\sqrt{\mu/\rho}$	$\sqrt{Y/\rho}$	Rod of radius r: $\sqrt{\omega r/2} \times \sqrt[4]{Y/\rho}$	$\frac{0.87 + 1.12\sigma}{1+\sigma} \sqrt{\mu/\rho}$
	$\sqrt{\frac{Y}{\rho} \frac{1-\sigma}{(1+\sigma)(1-2\sigma)}}$	$\sqrt{\frac{Y}{\rho} \frac{1}{2(1+\sigma)}}$	$\sqrt{\frac{\mu}{\rho} \frac{3\lambda' + 2\mu}{\lambda' + \mu}}$	Plate of thickness d: $\sqrt{\omega d/2} \times \sqrt[4]{\frac{Y}{\rho} \frac{1}{3(1-\sigma^2)}}$	
Wave-type conversion at boundary	Partly to shear wave	Partly to bulk wave	To Rayleigh wave as $\lambda \ll d$	To Rayleigh wave as $\lambda \ll d$	

Table I. Types of waves in isotropic solids

train to travel a given distance is measured. Standing-wave techniques are usually more suitable in the kilocycle range of frequencies, whereas pulse techniques are indicated for the megacycle range.

At this point we must note that, whereas only one type of wave—namely, longitudinal—exists in gases, additional forms of wave propagation are possible as the rigidity and structure of matter change. For example, liquids of high viscosity may support shear waves in addition to longitudinal waves. In isotropic solids we must distinguish between five different types of waves (Table 1). Finally, anisotropy will lead to a dependance of sound velocity on the direction of propagation, with regard to the crystal axes.

If the variation of pressure and the density in a sound wave are in phase, the wave propagates without loss of energy. However, once the period of the sound vibration is comparable with the time constant of a molecular or structural relaxation process, the density will lag behind the pressure. The loop area of the resulting pressure-density diagram then represents the energy that is lost per cycle. Another source of losses is multiple reflection or scattering that is caused, for example, by grain boundaries in polycrystalline materials. In principle, such losses may be determined in four different ways, as illustrated in Figure 2. They are (i) the time decay of forced vibrations in a standing-wave system, (ii) the decrease in amplitude with distance in progressive waves, (iii) the bandwidth of a harmonic mode of a resonating system, and (iv) the standing-wave ratio in an impedance tube. Many technical materials have been analyzed by these methods, and useful correlations have been established between their loss behavior and other physical properties.

We now come to the other application of sonics—namely, the processing of materials. It has been found that intense vibrations affect colloidal distributions, equalize electrolytic concentrations, and speed up aging processes. Also, by absorption in a lossy medium, intense vibrations may produce local heating effects as, for example, in the use of ultrasonics in medical therapy. In general, one may distinguish between two types of action—effects that are localized at interfaces between different kinds of media or between constituents of the same medium, and volume effects.

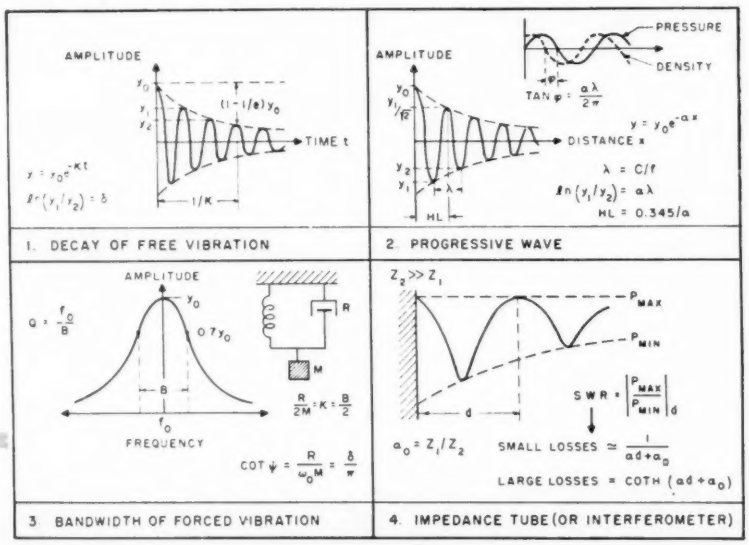


Figure 2. Basic techniques for attenuation measurements

Interface effects play a predominant role in power sonics and lead to a number of unusual phenomena. They are produced more readily than volume effects. For example, small bubbles or particles suspended in a liquid are subjected to drag forces in a sound field; similar forces come into play if a sound field interacts with an aerosol. This, then, is the physical basis for such processes as sonic stirring, degassing, and coagulation.

A particularly powerful phenomenon is cavitation. This is the breakdown of the cohesion of a liquid that is exposed to high tensile forces as the sound wave passes through it. Such breakdown usually occurs at the weakest points within the liquid. Tiny bubbles, dust particles, and particularly interfaces where poor wetting conditions exist, facilitate the onset of cavitation. As the term cavitation implies, cavities are formed in a liquid during the negative pressure phase of the sound wave; during the subsequent positive pressure phase, these cavities collapse, producing pressure peaks that may reach several hundreds of atmospheres. Under the influence of cavitation, steel

Figure 3. Ultrasonic Impact Grinder

surfaces may be pitted, oxide layers removed, bacteria disintegrated, or high polymers depolymerized. One particularly successful application of surface cavitation is exemplified by the Raytheon Impact Grinder (Figure 3); another is in the soldering of aluminum.

The frequency range covered by the above mentioned applications is extremely wide, both for the analytical uses and for the processing uses of sound energy. Their realization therefore entails widely different acoustic engineering practices, which is a characteristic feature—and sometimes a difficulty—of industrial ultrasonics. Table 2 lists a number of processes in which sound energy at high power levels can bring about a major improvement over existing methods. Of the four processes listed, ultrasonic degreasing and cleaning has already become an established industrial technique, and reliable equipment of 0.5 to 3 KW

PROCESS	DECREASING, CLEANING AND ELECTROPLATING	HOMOGENIZATION AND EMULSIFICATION	PROMOTION OF CHEMICAL REACTIONS	REFINEMENT OF METAL MELTS
Optimum frequency range	20—400 kc/sec	0.2—100 kc/sec	0.2—20 kc/sec	0.2—200 kc/sec
Type of substrate	Solid surfaces immersed in detergent liquid or electrolyte	Colloidal system	Substances responding to free radicals	Solidifying melts
Physical mechanism	Acoustic shearing and cavitation shock	Cavitation-induced turbulent mixing	Formation of hydroxyl groups by cavitation	Redistribution of nucleatron centers
Types of transducers	Magnetostrictive (ferro-electric)	Hydrodynamic Electromagnetic (Magnetostrictive)	Aero-mechanical Hydrodynamic Electromagnetic	Electrodynamic (Magnetostrictive)

Table II. Processing uses of high power sources

power rating whose manufacture, sales and maintenance have proved to be economical is commercially available. The other three processes have not yet been fully scaled up from laboratory type equipment to the magnitudes in power level and processing capacity that are necessary for industrial purposes. They constitute today's challenge to transducer designers and sonic system engineers.

The success of these processing methods depends largely on the availability of transducer mechanisms that are capable of generating sonic power economically, both in sufficient amounts and in a way compatible with the flow of industrial production. If the materials to be treated are encountered in small or medium-size batches, conventional transducers of the magnetostrictive or piezoelectric type may handle the job. (For example, in the brewery industry such units have been installed for the extraction of vegetable bitters from the hop.) They become impractical, however, for either very large batches or high rates of liquid flow. For large batches the recently developed hydrodynamic valve oscillators appear promising. Figure 4 shows such a hydrodynamic transducer coupled to a treatment tank, according to the method of J. V. Bouyoucos. Direct-current flow energy is provided by a pump. Fluctuations of pressure at the left side of the diaphragm produce a flow modulation owing to changes in the gap area of the valve. The resulting pressure changes at the valve end of the feedback loop are transmitted through the loop back to the diaphragm. Stable oscillations build up at a frequency for which the half-wavelength equals the loop length. Sound energy is extracted from the loop by a transmission-line section terminated by a dome-shaped acoustical window.

If cavitation-type treatment of a continuous liquid flow is desired rather than batch irradiation, the vibratory members of the transducer must become an integral part of the flow system. One approach to this task is the Sonic Oscillator developed by Submarine Signal

Company prior to its merger with Raytheon. This electromagnetically operated device provides a narrow flop-gap between two circular diaphragms resonant at 360 cps. Liquids have been subjected to violent cavitation at flow rates up to 300 gallons per hour with this transducer. Another method uses jets in combination with vibrating cantilever blades which are mounted in juxtaposition to the slit-shaped jet-orifice. Still other possibilities of subjecting liquid flow in a pipe to acoustic pressure amplitudes above cavitation threshold come to mind if one considers excitation of the flow pipe itself in one of its natural resonant modes. The goal of such endeavors, namely economical flow treatment at rates of the order of several hundred gallons per minute, now appear attainable due to recent developments in mechanical transducers operated by flow power.

We may now ask ourselves why the adoption of sonic techniques has been relatively slow in many areas of industry, despite the impressive list of potentially useful effects that have been described in the literature during the last 25 years. The answers to this question center around the following three key problems, which seem to pose themselves whenever the applicability to industry of a new tool, or process, or instrumentation is being evaluated: (i) the recognition of an existing need; (ii) the demonstration of technical feasibility; and (iii) the economics of both development and operation.

A clear-cut evaluation of these questions requires a close meeting of minds between the sonics experts, the production engineers, and management—and often a potentially useful approach is abandoned because of the lack of technical liaison. In other cases, the final completion of the development of a process that was shown to be feasible in small-scale laboratory tests did not take place because of excessive costs.

But even if the aforementioned three basic requirements are met, and a hopeful new product is born, a good deal of continued nursing, mainly in the form of technical education, is necessary to keep it alive and to adapt it to the ever-changing needs of industry. And this again can be achieved only by the cultivation of the relationships between the scientific-minded people in the laboratory and the practical-minded people in the field. The success or failure of ultrasonics as an industrial tool—like that of any other expedient—depends largely on the adeptness with which each particular effort is implemented: the evaluation in the laboratory of a new technique, the planning of the production of a new line of equipment, the engineering of an industrial processing or control system—they all require a purposeful integration of physical principles, technological considerations and economical requirements of the market.

At Raytheon a decisive step toward integration of the facilities and efforts in industrial ultrasonics was taken by Dr. I. A. Getting who in April 1957 set up an Ultrasonics Committee comprising members of the Commercial Engineering Division, the Research Division, the Sonar Department in the Government Engineering Division, and the Products Planning Department. During the past six months, this committee has been instrumental in preparing the ground for some new products in industrial ultrasonics by making full use of Raytheon's talents in acoustics.

The number of specific examples that could be given in this review of the present state of industrial ultrasonics is, of necessity, limited. It may however give the reader some feeling for the potential usefulness of acoustic instrumentation in a large variety of industrial tasks. Raytheon with its excellent facilities in research, transducer engineering, and underwater acoustics is predestined for a leading role in this field.

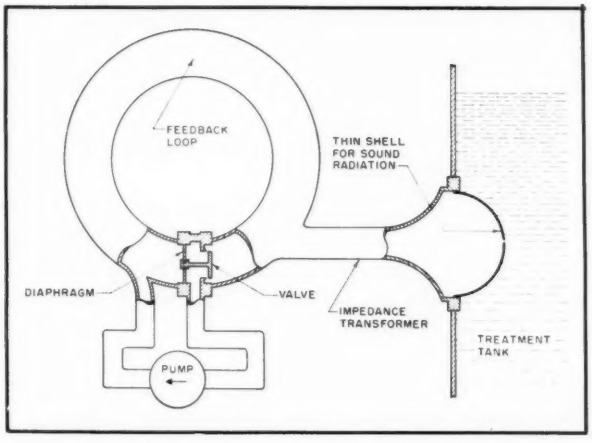
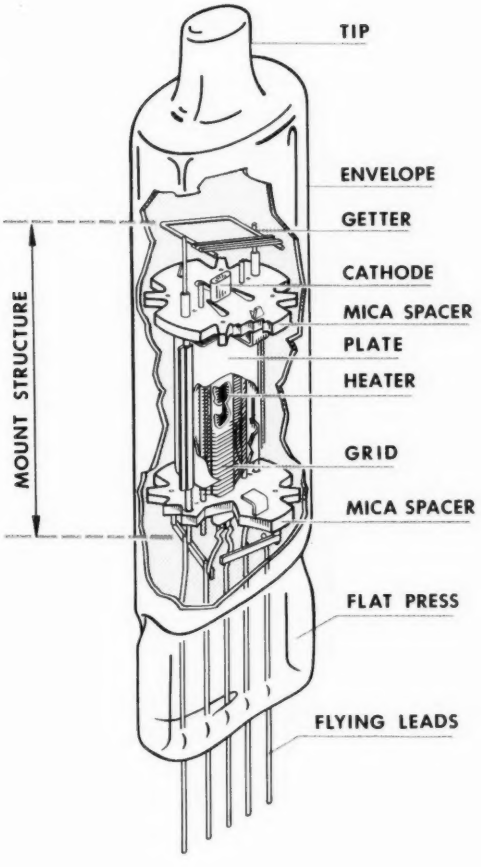


Figure 4. Hydrodynamic valve oscillator (according to J. V. Bouyoucos)



Vacuum tube production

F. Barry
Industrial Tube Division

The vacuum tube by its very nature is a complicated device, and its manufacture requires the coordinated efforts of no less than eight separate engineering departments—chemical, industrial, mechanical, quality control, welding, glass, general and applications. Even the hypothetically simple tube type that will be discussed here has innumerable small parts, each presenting a constant challenge to the engineer. The major engineering problem, however, is always: How can all these small parts best be joined to form a successfully functioning tube in the quickest, most economical fashion?

To fully appreciate the intricacies of this problem, it is advisable to examine a particular tube type. Figure 1 shows a cutaway view of a flat-press subminiature triode with its various parts labelled. This general type, made by the Special Tube Division of Receiving and Cathode Ray Tube Operations, has about 25 parts, and requires almost an equal number of perfect welds for its assemblage. Basically, there are only four stages to the manufacture of this or any other tube type—procuring and preparing the parts, assembling the mount, sealing-in and exhausting the bulbed mount, then stabilizing and testing the finished product—but each of these stages in turn breaks down into a number of small, taxing, and highly ingenious manipulations.

To begin with, each tube must be built up from large numbers of minute and delicate parts. Many of these tube parts, such as spacers, cathodes, plates, etc., may be procured from outside vendors. Upon receipt, they are inspected to a particular specification using normal sampling plan techniques and accordingly accepted or rejected. Many other parts, however, are made directly by Raytheon. This is particularly important in the case of grids. Because of their physical fragility and required tight dimensional tolerances, they are fabricated on highly specialized equipment right in the Special Tube factory. Referring back to the tube that we previously examined, it uses a 0.5 ± 0.01 inch long grid of oval cross section that is made from 0.001 inch gold-plated tungsten wire wound around two 0.015 ± 0.0005 inch siderods, approximately 200 turns to the inch. In addition to the dimensions indicated, the oval shape has major and minor diameters controlled to ± 0.001 inch. All in all, one quickly comes to the

Company prior to its merger with Raytheon. This electromagnetically operated device provides a narrow flop-gap between two circular diaphragms resonant at 360 cps. Liquids have been subjected to violent cavitation at flow rates up to 300 gallons per hour with this transducer. Another method uses jets in combination with vibrating cantilever blades which are mounted in juxtaposition to the slit-shaped jet-orifice. Still other possibilities of subjecting liquid flow in a pipe to acoustic pressure amplitudes above cavitation threshold come to mind if one considers excitation of the flow pipe itself in one of its natural resonant modes. The goal of such endeavors, namely economical flow treatment at rates of the order of several hundred gallons per minute, now appear attainable due to recent developments in mechanical transducers operated by flow power.

We may now ask ourselves why the adoption of sonic techniques has been relatively slow in many areas of industry, despite the impressive list of potentially useful effects that have been described in the literature during the last 25 years. The answers to this question center around the following three key problems, which seem to pose themselves whenever the applicability to industry of a new tool, or process, or instrumentation is being evaluated: (i) the recognition of an existing need; (ii) the demonstration of technical feasibility; and (iii) the economics of both development and operation.

A clear-cut evaluation of these questions requires a close meeting of minds between the sonics experts, the production engineers, and management—and often a potentially useful approach is abandoned because of the lack of technical liaison. In other cases, the final completion of the development of a process that was shown to be feasible in small-scale laboratory tests did not take place because of excessive costs.

But even if the aforementioned three basic requirements are met, and a hopeful new product is born, a good deal of continued nursing, mainly in the form of technical education, is necessary to keep it alive and to adapt it to the ever-changing needs of industry. And this again can be achieved only by the cultivation of the relationships between the scientific-minded people in the laboratory and the practical-minded people in the field. The success or failure of ultrasonics as an industrial tool—like that of any other expedient—depends largely on the adeptness with which each particular effort is implemented: the evaluation in the laboratory of a new technique, the planning of the production of a new line of equipment, the engineering of an industrial processing or control system—they all require a purposeful integration of physical principles, technological considerations and economical requirements of the market.

At Raytheon a decisive step toward integration of the facilities and efforts in industrial ultrasonics was taken by Dr. I. A. Getting who in April 1957 set up an Ultrasonics Committee comprising members of the Commercial Engineering Division, the Research Division, the Sonar Department in the Government Engineering Division, and the Products Planning Department. During the past six months, this committee has been instrumental in preparing the ground for some new products in industrial ultrasonics by making full use of Raytheon's talents in acoustics.

The number of specific examples that could be given in this review of the present state of industrial ultrasonics is, of necessity, limited. It may however give the reader some feeling for the potential usefulness of acoustic instrumentation in a large variety of industrial tasks. Raytheon with its excellent facilities in research, transducer engineering, and underwater acoustics is predestined for a leading role in this field.

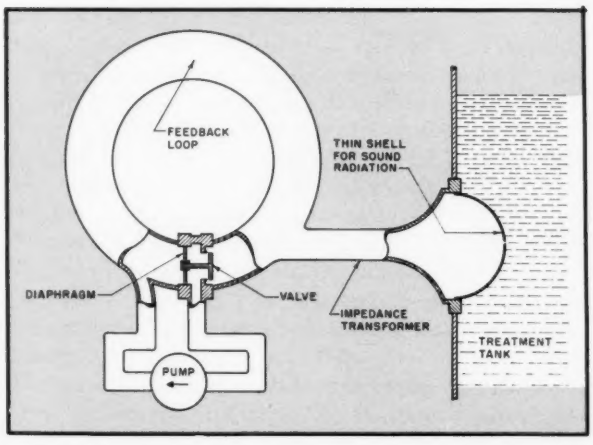
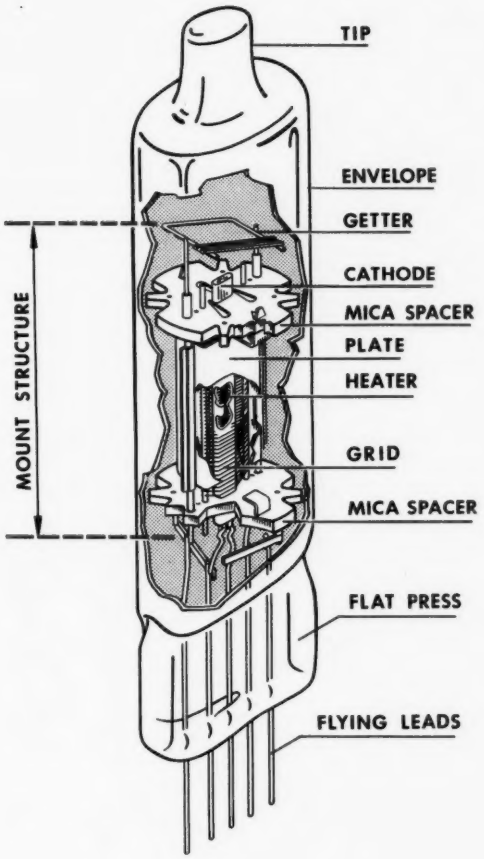


Figure 4. Hydrodynamic valve oscillator (according to J. V. Bouyoucos)



Vacuum tube production

F. Barry
Industrial Tube Division

The vacuum tube by its very nature is a complicated device, and its manufacture requires the coordinated efforts of no less than eight separate engineering departments—chemical, industrial, mechanical, quality control, welding, glass, general and applications. Even the hypothetically simple tube type that will be discussed here has innumerable small parts, each presenting a constant challenge to the engineer. The major engineering problem, however, is always: How can all these small parts best be joined to form a successfully functioning tube in the quickest, most economical fashion?

To fully appreciate the intricacies of this problem, it is advisable to examine a particular tube type. Figure 1 shows a cutaway view of a flat-press subminiature triode with its various parts labelled. This general type, made by the Special Tube Division of Receiving and Cathode Ray Tube Operations, has about 25 parts, and requires almost an equal number of perfect welds for its assemblage. Basically, there are only four stages to the manufacture of this or any other tube type—procuring and preparing the parts, assembling the mount, sealing-in and exhausting the bulbed mount, then stabilizing and testing the finished product—but each of these stages in turn breaks down into a number of small, taxing, and highly ingenious manipulations.

To begin with, each tube must be built up from large numbers of minute and delicate parts. Many of these tube parts, such as spacers, cathodes, plates, etc., may be procured from outside vendors. Upon receipt, they are inspected to a particular specification using normal sampling plan techniques and accordingly accepted or rejected. Many other parts, however, are made directly by Raytheon. This is particularly important in the case of grids. Because of their physical fragility and required tight dimensional tolerances, they are fabricated on highly specialized equipment right in the Special Tube factory. Referring back to the tube that we previously examined, it uses a 0.5 ± 0.01 inch long grid of oval cross section that is made from 0.001 inch gold-plated tungsten wire wound around two 0.015 ± 0.0005 inch siderods, approximately 200 turns to the inch. In addition to the dimensions indicated, the oval shape has major and minor diameters controlled to ±0.001 inch. All in all, one quickly comes to the

conclusion that grid making requires extremely careful and exact manufacturing control. The machine that fabricates a grid is in many respects similar to a conventional machinist's lathe and is, in fact, called a grid lathe (Figure 2).

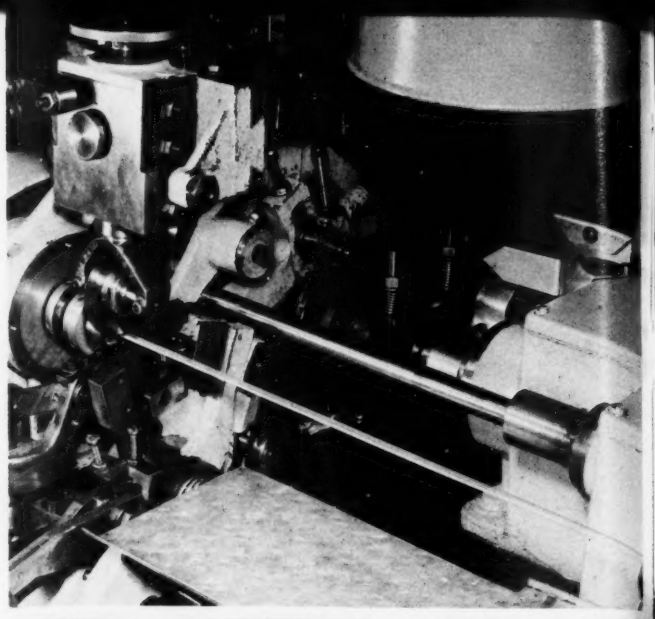
Another class of operation altogether consists of specially preparing some of these already formed parts. The cathode, primary source of electrons in the tube, is a case in point. Now although it is true that by heating the metallic cathode to a very high temperature, it would emit electrons, such an emitter would still be somewhat inefficient. Therefore, the bare nickel cathode is coated with a mixture of barium, strontium and calcium carbonates suspended in a binder, which will provide the proper emitting surface after processing. In a later stage, heating will cause these carbonates to break down into barium and strontium oxides, and it is primarily the free barium that gives good emission from an oxide-coated cathode. The coating is done automatically with loaded trays of cathodes moving on tracks at high speed past the spray nozzle and into a drying oven (Figure 3). The operation is repeated four times to build up a coat that is even and of the proper thickness.

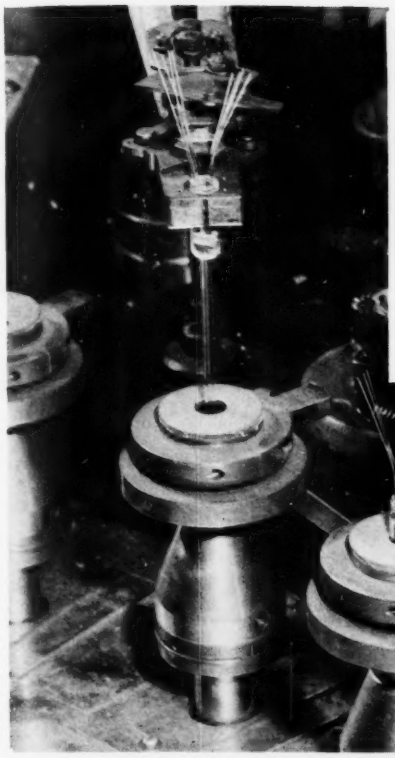
Once all the individual parts have been obtained and prepared, the next step is to assemble them into a complete unit. By and large, the majority of tubes produced today are put together by hand using a production line technique (Figure 4). The work is difficult and tedious, yet with a good team of operators it is possible to consistently turn out sound tubes with only a small percentage of scrap. The carefully welded unit of cathode, plate, grid, spacers, etc. (known as the "mount assembly") has to be placed inside a glass bulb, and is then ready to be "sealed in" and processed.

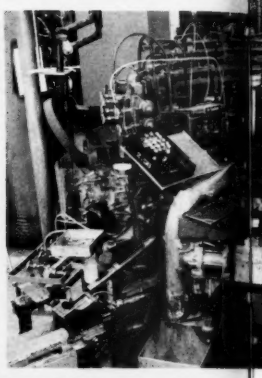
When we speak of sealing a tube in, we are describing that step in the manufacturing process in which the glass envelope that surrounds the tube is physically connected to a preformed glass stem containing the tube pins or, as in the case of Raytheon's flat press tube type, the glass envelope is molded around the tube pins to form a vacuum tight seal.

At this point in its fabrication cycle the tube has not yet been evacuated, but with the sealing of the base, evacuation is now possible by connecting a vacuum pump to the glass tube that forms the top of the bulb. (The term "tubulation" is used to refer to this part of the tube.) Although it is possible to evacuate each tube separately or on some type of multiple trolley, such a procedure is too slow for high volume production. Thus, almost all the tubes that are manufactured in large volumes are exhausted and processed on high speed rotary equipment.

One particular machine that is used (Figure 5) consists of a large rotating table upon which the tubes to







Figure

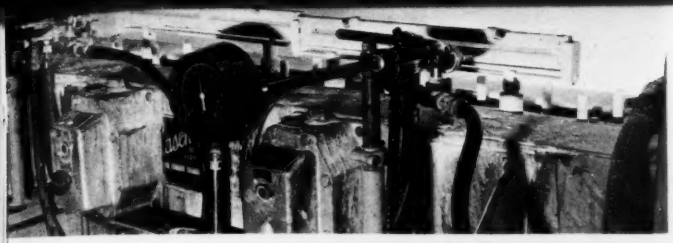


Figure 3.

Figure 2.

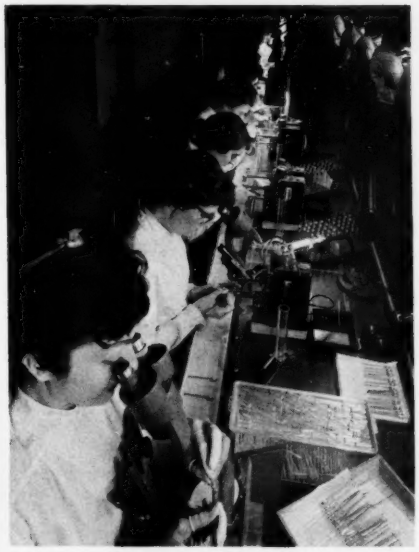


Figure 4.

Figure 5.

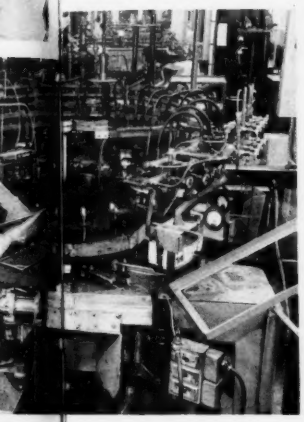
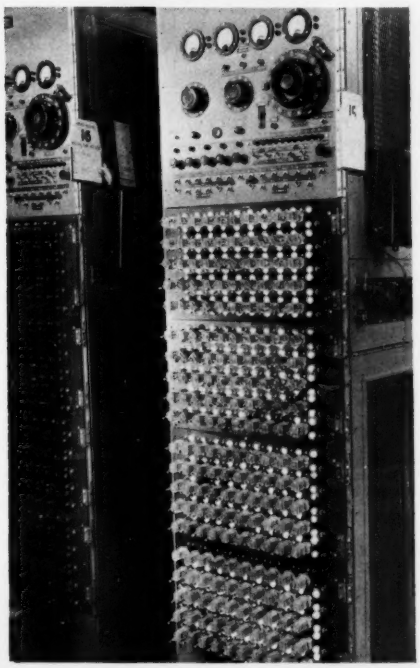


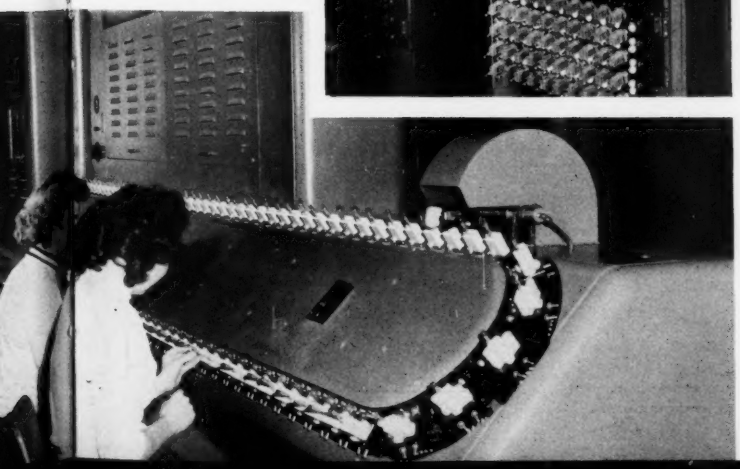
Figure 6.

Figure 8.

Figure 7.

Figure 9





be processed are continually loaded and then automatically indexed from position to position through the processing cycle. A closer look at the machine discloses the fact that there are ports (vacuum tight couplings that will accept the tubulation) designed to hold the tube during the processing cycle, while at the same time continually pumping (evacuating) the tube. A normal machine contains 16 such ports and makes one complete revolution every 96 seconds, thereby yielding 600 tubes per hour (6 seconds per tube).

It's interesting to follow the progress of a sealed-in tube from the time that it is loaded into the machine until it is removed. The operator (or possibly even a mechanical transfer device operating between the sealing-in and the exhaust machines) places the sealed-in but not evacuated tube, tubulation end down, into a port at position number one (Figure 6). The machine indexes, pumping is begun and the tube is carried into a bakeout oven that is maintained at a temperature of 500 degrees centigrade. The purpose of this step is to drive off all gas and water vapor from inside the glass bulb and stem. After indexing through a number of positions within the oven, the tube re-emerges, whereupon a high voltage is applied to the heater to cause breakdown of the cathode carbonates. The metal parts are heated up by bombers (RF induction heaters), and the combination of this heat and the heat applied to the cathode by lighting the heater causes the chemical action known as cathode breakdown to take place (Figure 7). Tip-off, the sealing of the exhaust tubulation, takes place while the tube is still indexing around the exhaust machine. At the end of the cycle the getter is flashed by RF induction heating. The getter (a barium-aluminum-nickel alloy) acts as a pump and cleans up any residual gas left in the tube after tip-off.

After exhausting we have one more step in the process—aging. To complete the cathode breakdown and to stabilize the tube's characteristics, the tubes are burned at specified voltages and/or currents for varying periods of time (Figure 8).

As the last stage of production, there is testing. To make this job more accurate and to increase the repeatability of test results, an automatic test set (Figure 9) has been developed. This set tests for all important characteristics, separates the rejects from the good tubes, and gives the engineer a running record of his scrap results hour by hour.

Considering that the many steps mentioned here haven't been discussed in any real detail, it can readily be seen that the manufacture of vacuum tubes is indeed almost as much art as science, an art which requires the skills and cooperative efforts of hundreds of people.

Ultrasonic Soldering of

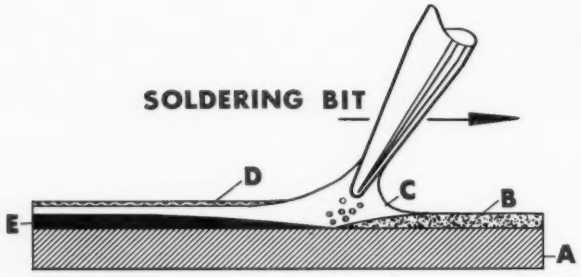


Figure 1. Diagrammatic representation of soldering action with ultrasonic abrasion. (A) Base metal. (B) Oxide surface. (C) Molten solder (bubbles represent oxide cavitation). (D) Oxides on surface of molten solder. (E) Solidified solder.

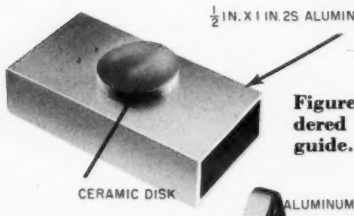


Figure 2. Ceramic disk soldered to aluminum waveguide.

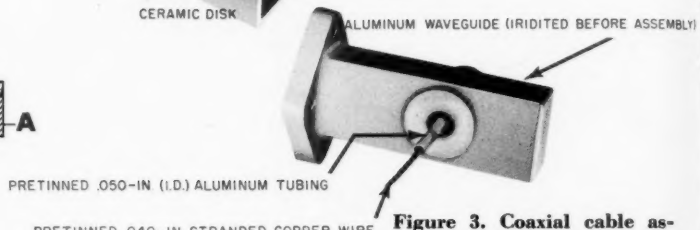

ALUMINUM WAVEGUIDE (IRIDITED BEFORE ASSEMBLY)
PRETINNED .050-IN (I.D.) ALUMINUM TUBING
PRETINNED .040-IN. STRANDED COPPER WIRE

Figure 3. Coaxial cable assembly made from parts pretinned ultrasonically.

The best way to solder aluminum is generally considered to be one of the most controversial problems in the art of metal joining, and many experts in the field disagree as to the best materials and techniques. The use of conventional soldering methods for joining aluminum is at best extremely difficult because aluminum cannot be easily wetted or tinned with most soldering alloys.

When joining any metals by the soldering process, the strength of the joint and its ability to resist corrosion are major factors to be considered, along with the ease of operation. In the case of aluminum, a tough glass-like oxide skin forms on a newly cleaned surface almost instantly, and resists all but the most corrosive fluxes. The use of these corrosive fluxes increases the danger from flux inclusion in the joint, and results in a greater possibility of subsequent deterioration of the joint strength because of this flux inclusion.

Some success has been obtained through abrasion of the aluminum surface while the area is covered with molten solder. Although a sharp tool or stiff wire is usually used for this, the aluminum oxide cannot always be completely removed, and the resulting surface is not completely tinned. Besides being time-consuming, this operation is costly, and the subsequent joint is not always sound. Furthermore, this method of tinning aluminum cannot be used on wire and thin strips of metal.

It has been known for many years that ultrasonic vibrations applied to metal surfaces cause erosion of those surfaces. These same vibrations, when applied to a puddle of molten solder on the metal, cause an explosion of small gaseous pockets within the solder, accompanied by a disrupting effect on the oxides. See Figure 1. The molten solder flows into the pits caused by the ultrasonic erosion, and the oxide floats to the surface of the solder, from which it can be removed. If "dry joints" are to be avoided, this cleaning of the solder surface is essential. Once a clean tinned surface has been obtained, joining of two parts can be effected by normal methods (approximately 45 seconds is usually required to obtain a clean joint surface of about one-half inch square).

The value of ultrasonic vibrations in soldering was discovered and first used by the Germans as early as 1936. The chief advantages of this method are its elimination of fluxes, resulting in clean joints free of the corrosive action of fluxes, and its elimination of the time-consuming and costly cleaning processes.

Since 1936, much has been written about the joining of metals with ultrasonic vibrations, some persons claiming that ultrasonic soldering is the answer to all soldering problems, others claiming that it is limited in its use primarily to those applications in which fluxes cannot be tolerated. The author believes that, although many limitations do exist and much research

Aluminum

C. Campbell
Missile Systems Division

Some recent work at the Bedford Lab promises to eliminate many of the problems associated with the soldering of aluminum. Their brazing and soldering group has been experimenting with a fluxless soldering alloy which has performed very well to date in joining aluminum. The solder is essentially a zinc-base alloy and includes no flux, nor does it require the use of flux to wet the aluminum surface. When the solder is wiped over the heated joint area, there is an immediate action and no rubbing-in is required, eliminating many of the processes which have caused difficulty in the past. Its melting range is between 400 and 450 deg. C.

Sample joints of various types of aluminum have been subjected to tests such as salt-spray, humidity, heat treatment, chemical cleaning and coatings, with no harmful effects noted. All specimens were ½-inch wide stock with ½-inch single lap. Under stress, all specimens of thickness less than 3/16-inch failed outside the joint. Specimens of thickness greater than 3/16-inch failed in shear at 8000 psi. Since these tests were made, the alloy has been improved to a point where a minimum of 10,000 psi shear is anticipated.

The solder may also be used as a filler metal, and lends itself well to machining. Further information can be obtained from C. Campbell.

has yet to be done, the joining of aluminum by the use of ultrasonic energy can be employed more effectively than present conventional methods. With special equipment, any piece of metal that can be pre-tinned or soldered with a soldering iron or torch can be soldered ultrasonically. Dissimilar metals can be joined, fine wires of aluminum and copper can be joined without stripping, as can wires which have been coated with Formvar or other insulating materials. Surfaces which have been treated for corrosion resistance can be tinned without prior cleaning; furthermore, no plating is required prior to soldering.

In production soldering applications, it is possible to use ultrasonic equipment in the pre-tinning of parts which are slated for later assembly by conventional soldering irons.

Ultrasonic equipment is available for dip-soldering and conventional soldering with an iron, as well as for welding and brazing. Many applications of ultrasonic soldering require the design of soldering tips of special size and shape, each one tailored to the specific need.

At the Bedford Laboratory, many noteworthy applications of ultrasonic soldering irons and baths have been made. Strong joints have been made with aluminum and bronze, aluminum and brass, and aluminum and magnesium. Aluminum has been soldered to ceramics (Figure 2) and to transite. In addition to these applications with aluminum, stainless steel has been soldered to ceramics, and brass has been soldered to transite.

A successful production application of ultrasonics to aluminum joining has been made in a coaxial cable assembly (Figure 3). The pre-tinned cable is assembled in the aluminum tubing with a resulting joint so strong that it withstands stresses that break the cable itself. The tubing, which has an inside diameter of 0.05 inch, was ultrasonically tinned after being anodized. Figure 4 shows the equipment used for this assembly.

The use of ultrasonic energy for joining metals will probably never completely replace welding and riveting, but the process is economically sound for many applications. Considerable work has yet to be done in the perfection of soldering alloys which provide both corrosion resistance and strength. The preliminary work has already been done; it is only a matter of time before the use of ultrasonics becomes completely conventional in the many fields to which it is especially well suited.

WAVEGUIDE IN POSITION FOR FINAL ASSEMBLY
SPECIALLY DESIGNED SOLDER POT
ULTRASONIC POWER UNIT
ULTRASONIC SOLDERING UNIT

Figure 4. Ultrasonic soldering equipment used for coaxial cable assembly.

PATENTS
—Their Origin, Nature & Subject Matter

B. Lemlein
Law Department

ORIGIN

Patents in the Anglo-American society appear to have had their origin in the practice of the British Crown of granting royal monopolies.

Although initially bestowed as a stimulant to commerce, it was not long before the grants were awarded at the whim of the Throne to royal favorites and to those making financial gifts to the King. Court decisions during the late reign of Queen Elizabeth I and the early reign of King James I recognized the authority of the Crown to create monopolies and grant patents, but distinguished between those that were good and those that were bad. Where the public interest was served, for example, where the grantee had been rewarded for inventing a new device or introducing a new trade into the realm, the monopoly was upheld, but where the grant had been conferred in the absence of public benefit, for example, at the mere pleasure of the Monarch, the grant was struck down. While the Courts were powerless to prevent the bringing of these monopolies into being, they were able to remedy abuses of the royal prerogative, which were deemed contrary to Magna Charta, by punishing the monopolist.

In order to alleviate the foregoing situation and bind the Crown to the granting of only "good" patents, Parliament enacted into written law (Statute 21, James I) what had previously been the unwritten common or judge-made law. This Statute, in effect, provided that all monopolies previously and subsequently granted (with certain specific exclusions) were void, except those given, for limited periods of time, to first and true inventors of new manufacturing methods.

This Parliamentary Act conferred no new rights. It did, however, restrict the scope of the monopolies that the Crown could grant, although the granting remained within the exclusive power of the Sovereign. To a large extent, this Statute and the great body of British court decisions before and under it constitute the basis of the American patent law system about which more will be said below and in subsequent articles in this series.

NATURE

Article I, Section 8, of our Constitution provides:

"The congress shall have the power. . . . To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

Pursuant to this Constitutional authority, Congress has enacted from time to time laws governing the granting of patents. The first legislation occurred in 1790 and the latest in 1952.

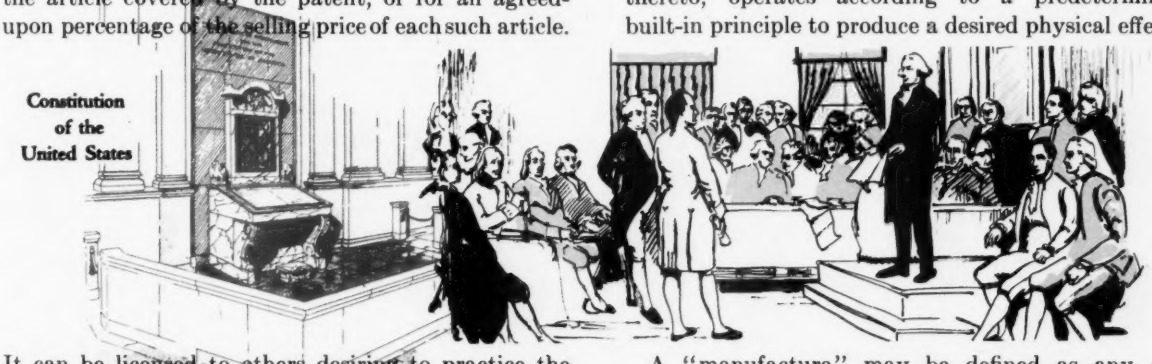
For the purposes of this discussion, portions of certain Sections of Title 35 of the United States Code, the present Patent Law, governing the grant, subject matter and term of a patent, and the nature of the description of the invention covered thereby, may be paraphrased in the following manner:

Anyone who invents any new and useful process, machine, manufacture, or composition of matter and who presents such a full, clear and concise written description thereof, and of the manner of making and using it, that any person skilled in the art can duplicate the inventor's results is entitled to a patent. The patent secures to the patentee the negative right or monopoly to exclude others from making, using or selling the invention in the United States for a period of 17 years.

While a monopoly in any form necessarily takes rights away from some in favor of others and is therefore generally abhorred, any disadvantages of the kind of monopoly resulting from the granting of a patent are considered to be outweighed by the benefits flowing to the public. By virtue of the inventor's disclosure of his invention, the sum total of mankind's knowledge is added to, investment is encouraged with a consequent increased standard of living, further advances in that art and the opening up of new arts are stimulated and, in view of the eventual surrender of the invention to the public, there is an addition to the common property.

The previous paragraph referred to only the public benefit of patents. The patentee, however, is also intended to gain from the grant. As stated, the issuance of the patent does confer upon the patentee a limited monopoly and he is thereby put in a position, and properly so, to reap a pecuniary reward during the life of the patent.

A patent is personal property and, as such, can be treated in many of the same ways as other forms of this type of property. It can be sold outright, passing complete legal title to a purchaser, for a fixed amount of money payable either in a lump sum or in installments, or for a fixed amount of money for each sale of the article covered by the patent, or for an agreed-upon percentage of the selling price of each such article.



It can be licensed to others desiring to practice the invention covered by the patent. In this case, the patentee remains the sole owner and the licensee is given no rights which enable him to treat the patent as his property. The license is merely a permission to practice the invention with freedom from suit for infringement. This privilege can be granted for the life of the patent or for some lesser period of time. The compensation to the patentee can, as in the case of a sale of the patent, be a fixed sum of money payable in a lump sum in advance or in installments at stated times during the life of the agreement. It may be based upon the licensee's activities under the license; that is, a royalty payment for each sale of the patented article, either a fixed amount of money or a percentage of the selling price.

Monetary reward is not the only method of exploiting a patent. Another method often used is the exchange of royalty-free licenses between two parties, the values exchanged being substantially equal on both sides.

There are a number of other ways by which a patent may be exploited for its owner's benefit, those mentioned being only the most usual.

SUBJECT MATTER

Assuming an idea to be novel, to be useful and to possess a degree of ingenuity such that it would not have been obvious at the time of its conception to a person having ordinary skill in the art to which it pertains, it may be patented if, as indicated above, it consists of a process, machine, manufacture or composition of matter. Actually there are two other classes of patentable subject matter, designs and plants, but inasmuch as these are of relatively minor significance, they will not be explored in this article.

A "process" may be defined as a *sequence of controlled manipulations* or a *mode of treatment* or a *series of acts*, performed on some material to produce a desired physical change in said material.

A "machine" may be defined as an *instrumentality*, usually a plurality of coacting mechanisms such as levers, gears, etc., which, when power is applied thereto, operates according to a predetermined, built-in principle to produce a desired physical effect.

A "manufacture" may be defined as any *end-product*, distinct from the materials of which it is made or the particular method of or means for producing it, which is devised by man for the performance of some useful function. This class of invention is of such wide scope and sometimes so difficult to distinguish from a machine or composition of matter, that a few examples, such as the parts of a machine, tools, containers, appliances, etc., may be more helpful than specific definition.

A "composition of matter" may be defined as a *combination of ingredients* mutually cooperating to provide a product whose attributes are different from the individual attributes of the ingredients and also different from the mere sum of the attributes of its ingredients.

There are many kinds of ideas which, although they

sometimes seemingly satisfy one or the other of the definitions of patentable subject matter set forth above, have been held by judicial or quasi-judicial tribunals not to be appropriate subject matter for patents.

Systems of doing business are not patentable. An example is the drive-in theatre, as covered by Patent No. 1,909,537. This patent claimed an outdoor theatre consisting of a stage, alternate rows of driveways and stall-ways, the stall-ways being receptive of automobiles and being angularly disposed with respect to the stage so that a clear view could be had free of obstruction from the automobiles ahead. One Court, in considering this patent, held that the invention came under a patentable classification, a manufacture or machine. Another Court, in a different jurisdiction, held that the drive-in theatre was no more than a plan for the transaction of business, and regardless of its novelty or usefulness, or its revolutionary character and its benefit to humanity, it was a mere idea, not of itself patentable. Because of these conflicting opinions, an attempt was made to carry this case to the United

This one Raytheon magnetron (shown below with all its components) is actually a composite of many inventions, and incorporates within itself at least one successful example from each patent category.

The cathode coating consists of a combination of ingredients, thereby qualifying as a "composition of matter".

The entire tube constitutes an article of "manufacture".

The anode structure is assembled by alternately stacking laminae with silver solder discs, then brazing in a furnace under controlled conditions. This system of assemblage is illustrative of a "process".

The mechanism for actuating the tuner is an example of a "machine".

States Supreme Court. However, this Court denied certiorari; that is, it refused to hear the appeal, and in so doing, it in effect sanctioned the view of the second Court referred to above.

Mental processes are not patentable. An example is the combination of sound and light for aesthetic expression as covered by Re. Patent No. 16,825. This patent claimed a method which consisted of producing sounds in time, rhythmic relationship, and flooding the area of audibility with light of gradual variations in color and intensity in timed relationship with the emotional content of a succession of the sounds. The Court stated that it could find no authority in the law for the issuance of a patent for results dependent upon such intangible, illusory and nonmaterial things as emotional or aesthetic reactions. Such subject matter could not be held to constitute a process, machine, manufacture or composition of matter susceptible of patent protection.

Scientific principles are not patentable. An example is the exposure of food to ultraviolet rays to impart antirachitic properties thereto. Patent No. 1,680,818 covered a process consisting of subjecting food to the action of ultraviolet rays, such as are produced by a quartz mercury vapor lamp, for a period sufficient to effect antirachitic activation but limited to avoid subsequent injury to the antirachitic principle. The patent was struck down, one of the concurring opinions pointing out that ultraviolet light is a natural form of energy and like the sun, its source, is the property of all mankind and cannot be made the subject of a monopoly.

Some other examples of unpatentable subject matter, by no means complete, are printing arrangements, products of nature, and results as distinguished from the method of or apparatus for achieving the same.

Within the space limitations of this article, the origin, nature and subject matter of patents have necessarily been sketchily described. From time to time in the future, additional articles will be presented on other aspects of patents thought to be of interest.

Inventions

Name	*Field of Invention*
M. FLORIDIA H. TAYLOR A. SCARPA	Transistor Switch
FRANK NUNEZ	Cathode Ray Tube Anode
LOUIS GOODMAN	Stylus
RAY ELLIS, JR.	Decomposition of Silicon Tetraiodide
EDWIN E. TURNER	Bender Type Transducer
LEONA MOGEY	Conductive Shields
THOMAS WEIL	Transistorized Power Supply
ARON J. ARONIAN	Lead-in Pins
DUANE B. HAAGENSEN	Electronic Oven System
HOWARD SCHARFMAN	Broadband Thruplexer
H. P. MINOT T. BAKER A. SLATER	Ferrite Modulators
G. H. HILTON F. M. CAMERON, JR.	Regulator for Sandwich Cooker

Publications and Papers

A. Blattel	"Fast Operation Time in Subminiature Tubes"
D. L. Bobroff and H. A. Haus	"Uniqueness and Orthogonality of Small Signal Solutions in Electron Beams"
V. M. Curcio and F. J. Hynes	"Alumina Ceramics Fired in a Non-Oxidizing Atmosphere"
K. V. Curtis and T. J. Kelly	"Improvement in Radar Presentation"
A. S. Dwyer	"Plating of Magnesium"
W. T. Eriksen	"The Modulation of Liquid Induced Surface Currents on Germanium Surfaces"
W. T. Eriksen and E. J. Handly	"A Tube That Tells Time"
J. S. Gaziano	"Driver Tube for Hybrid Auto Receivers"
N. E. Gibbs	"Remarks on Problems of Scaling in Industrial Ultrasonics"
B. P. Goldsmith	"Statistical Engineering in Vacuum Tube Manufacturing"
O. J. Guentert	"On the Determination of Ferrite Structures by X-Rays"
T. F. Hueter	"Unsolved Problems in Acoustics—Sonic Engineering"
P. W. Kiesling, Jr.	"A Temperature Stable Transistor Multiplex Terminal"
M. R. Krasno	"Use of Infrared Systems in Marine Navigation and Communication"
W. Loening	"Thermal Inertia Study on a Radar Antenna for High Speed Aircraft"
M. Mark, M. Stephenson, and C. Goltsos	"Expendable Evaporative-Gravity Cooling Systems for Electronic Equipment"
D. R. S. McColl and G. L. Burton	"The Effects of Terrain Bias Error on Doppler Navigator Accuracies"
M. McFadden	"Materials and Process Engineering in Missile Research and Development"
J. Osepchuk	"Delay Line for a High-Powered "M" Type Backward-Wave Oscillator"
R. Paananen	"Thermal Properties of Tungsten versus Copper for Electron Tube Delay Lines"
D. M. Palamountain	"Establishing a Practical Routine for Measuring TV and Radio Tube Quality in the Customer's Plant"
J. R. Patel	"Arrangements of Dislocations in Plastically Bent Crystals"
R. A. Pucel	"The Spacistor"
R. A. Pucel and C. Lanza	"The Spacistor—A New High-Frequency Semiconductor Amplifier"
J. P. Reynolds	"Practical Considerations for the Application of Junction Transistors in Chopper Circuits"
J. Sardella and R. Wonson	"A New High-Frequency Diffused Base Transistor"
D. Schiff and S. Ziering	"Yvon's Method for Slabs"
M. H. Sirvetz and J. Zneimer	"Microwave Properties of Polycrystalline Rare Earth Garnets"
H. B. Smets	"Nuclear Power Plant Transfer Functions"
V. Vartanian	"A 6 Watt Servo Amplifier for Operations From −55°C to +125°C"
R. Wood and T. J. White	"Operation of a Specially Designed DC Differential Amplifier Tube"

Errata from past issues ——

D. L. McMurtrie and J. P. Ward	"The Behaviour of Oxygen in Deformed Silicon"
J. R. Patel and S. Lederhandler	"Triggering in Reversible Half-Wave Magnetic Amplifier"
W. H. Ryer and W. E. Sheehan	"Present Status of Transistor Receiver Design Procedures"

sometimes seemingly satisfy one or the other of the definitions of patentable subject matter set forth above, have been held by judicial or quasi-judicial tribunals not to be appropriate subject matter for patents.

Systems of doing business are not patentable. An example is the drive-in theatre, as covered by Patent No. 1,909,537. This patent claimed an outdoor theatre consisting of a stage, alternate rows of driveways and stall-ways, the stall-ways being receptive of automobiles and being angularly disposed with respect to the stage so that a clear view could be had free of obstruction from the automobiles ahead. One Court, in considering this patent, held that the invention came under a patentable classification, a manufacture or machine. Another Court, in a different jurisdiction, held that the drive-in theatre was no more than a plan for the transaction of business, and regardless of its novelty or usefulness, or its revolutionary character and its benefit to humanity, it was a mere idea, not of itself patentable. Because of these conflicting opinions, an attempt was made to carry this case to the United

This one Raytheon magnetron (shown below with all its components) is actually a composite of many inventions, and incorporates within itself at least one successful example from each patent category.

The cathode coating consists of a combination of ingredients, thereby qualifying as a "composition of matter".

The entire tube constitutes an article of "manufacture".

The anode structure is assembled by alternately stacking laminae with silver solder discs, then brazing in a furnace under controlled conditions. This system of assemblage is illustrative of a "process".

The mechanism for actuating the tuner is an example of a "machine".

States Supreme Court. However, this Court denied certiorari; that is, it refused to hear the appeal, and in so doing, it in effect sanctioned the view of the second Court referred to above.

Mental processes are not patentable. An example is the combination of sound and light for aesthetic expression as covered by Re. Patent No. 16,825. This patent claimed a method which consisted of producing sounds in time, rhythmic relationship, and flooding the area of audibility with light of gradual variations in color and intensity in timed relationship with the emotional content of a succession of the sounds. The Court stated that it could find no authority in the law for the issuance of a patent for results dependent upon such intangible, illusory and nonmaterial things as emotional or aesthetic reactions. Such subject matter could not be held to constitute a process, machine, manufacture or composition of matter susceptible of patent protection.

Scientific principles are not patentable. An example is the exposure of food to ultraviolet rays to impart antirachitic properties thereto. Patent No. 1,680,818 covered a process consisting of subjecting food to the action of ultraviolet rays, such as are produced by a quartz mercury vapor lamp, for a period sufficient to effect antirachitic activation but limited to avoid subsequent injury to the antirachitic principle. The patent was struck down, one of the concurring opinions pointing out that ultraviolet light is a natural form of energy and like the sun, its source, is the property of all mankind and cannot be made the subject of a monopoly.

Some other examples of unpatentable subject matter, by no means complete, are printing arrangements, products of nature, and results as distinguished from the method of or apparatus for achieving the same.

Within the space limitations of this article, the origin, nature and subject matter of patents have necessarily been sketchily described. From time to time in the future, additional articles will be presented on other aspects of patents thought to be of interest.

Inventions

Name	*Field of Invention*
M. FLORIDIA H. TAYLOR A. SCARPA	Transistor Switch
FRANK NUNEZ	Cathode Ray Tube Anode
LOUIS GOODMAN	Stylus
RAY ELLIS, JR.	Decomposition of Silicon Tetraiodide
EDWIN E. TURNER	Bender Type Transducer
LEONA MOGEY	Conductive Shields
THOMAS WEIL	Transistorized Power Supply
ARON J. ARONIAN	Lead-in Pins
DUANE B. HAAGENSEN	Electronic Oven System
HOWARD SCHARFMAN	Broadband Thruplexer
H. P. MINOT T. BAKER A. SLATER	Ferrite Modulators
G. H. HILTON F. M. CAMERON, JR.	Regulator for Sandwich Cooker

Publications and Papers

A. Blattel	"Fast Operation Time in Subminiature Tubes"
D. L. Bobroff and H. A. Haus	"Uniqueness and Orthogonality of Small Signal Solutions in Electron Beams"
V. M. Curcio and F. J. Hynes	"Alumina Ceramics Fired in a Non-Oxidizing Atmosphere"
K. V. Curtis and T. J. Kelly	"Improvement in Radar Presentation"
A. S. Dwyer	"Plating of Magnesium"
W. T. Eriksen	"The Modulation of Liquid Induced Surface Currents on Germanium Surfaces"
W. T. Eriksen and E. J. Handly	"A Tube That Tells Time"
J. S. Gaziano	"Driver Tube for Hybrid Auto Receivers"
N. E. Gibbs	"Remarks on Problems of Scaling in Industrial Ultrasonics"
B. P. Goldsmith	"Statistical Engineering in Vacuum Tube Manufacturing"
O. J. Guentert	"On the Determination of Ferrite Structures by X-Rays"
T. F. Hueter	"Unsolved Problems in Acoustics—Sonic Engineering"
P. W. Kiesling, Jr.	"A Temperature Stable Transistor Multiplex Terminal"
M. R. Krasno	"Use of Infrared Systems in Marine Navigation and Communication"
W. Loening	"Thermal Inertia Study on a Radar Antenna for High Speed Aircraft"
M. Mark, M. Stephenson, and C. Goltsos	"Expendable Evaporative-Gravity Cooling Systems for Electronic Equipment"
D. R. S. McColl and G. L. Burton	"The Effects of Terrain Bias Error on Doppler Navigator Accuracies"
M. McFadden	"Materials and Process Engineering in Missile Research and Development"
J. Osepchuk	"Delay Line for a High-Powered "M" Type Backward-Wave Oscillator"
R. Paananen	"Thermal Properties of Tungsten versus Copper for Electron Tube Delay Lines"
D. M. Palamountain	"Establishing a Practical Routine for Measuring TV and Radio Tube Quality in the Customer's Plant"
J. R. Patel	"Arrangements of Dislocations in Plastically Bent Crystals"
R. A. Pucel	"The Spacistor"
R. A. Pucel and C. Lanza	"The Spacistor—A New High-Frequency Semiconductor Amplifier"
J. P. Reynolds	"Practical Considerations for the Application of Junction Transistors in Chopper Circuits"
J. Sardella and R. Wonson	"A New High-Frequency Diffused Base Transistor"
D. Schiff and S. Ziering	"Yvon's Method for Slabs"
M. H. Sirvetz and J. Zneimer	"Microwave Properties of Polycrystalline Rare Earth Garnets"
H. B. Smets	"Nuclear Power Plant Transfer Functions"
V. Vartanian	"A 6 Watt Servo Amplifier for Operations From −55°C to +125°C"
R. Wood and T. J. White	"Operation of a Specially Designed DC Differential Amplifier Tube"

Errata from past issues ——

D. L. McMurtrie and J. P. Ward	"The Behaviour of Oxygen in Deformed Silicon"
J. R. Patel and S. Lederhandler	"Triggering in Reversible Half-Wave Magnetic Amplifier"
W. H. Ryer and W. E. Sheehan	"Present Status of Transistor Receiver Design Procedures"

Here are some of the features of this line of RAYTHEON RELIABILITY + SUBMINIATURE TUBES:

- Reduced vibration output after shock
- Increased clearance between elements
- Controlled operation time
- Tighter limits for important characteristics
- Greater uniformity
- Lower microphonics
- Better resistance to shock and fatigue
- Pulse emission specification (where applicable)

ASSEMBLED UNDER GLASS

Raytheon RELIABILITY + Subminiature Tubes are made and assembled under glass in air conditioned, lint-free and dust-proof quality controlled areas. Every detail of construction is subject to the most advanced mechanical techniques including semi-automatic jigs and fixtures so that operator skill is no longer the critical factor. That's why these Raytheon Subminiature Tubes provide *Reliability Plus* performance.

RAYTHEON RELIABLE SUBMINIATURE TUBES For Guided Missile, Military and All Other Critical Applications
TYPICAL CHARACTERISTICS

TYPE	DESCRIPTION	Vibration Output* (maximum) mVac	Vibration Output** peak to peak mV	Heater Volts	Heater mA	Plate Volts	Plate mA	Cathode Bias Resistor ohms	Screen Volts	Screen mA	Amplification Factor	Mutual Conductance μmhos
CK5702WB	Video Amplifier, Pentode	50	240	6.3	200	120	7.5	200	120	2.6	—	5000
CK5703WB	High Frequency Triode	10	50	6.3	200	120	9.4	220	—	—	25.5	5000
CK5704†	High Frequency Diode	—	25	6.3	150	Max. inverse peak = 460 volts; max. I_0 = 10 mA						
CK5744WB	High Mu Triode	15	75	6.3	200	250	4.2	500	—	—	70	4000
CK5783WB	Voltage Reference	50	—	Operating voltage approximately 85 volts between 1.5 and 3.5 mA								
CK5784WB	RF Mixer Pentode	75	300	6.3	200	120	5.5	230	120	4.1	—	3200
CK5787WB	Voltage Regulator	50	—	Operating voltage approximately 98 volts between 5 and 25 mA								
CK6247WA	Low Microphonic	2.5	25	6.3	200	250	4.2	500	—	—	60	2650
CK6533WA	Low Microphonic Triode	1.0	—	6.3	200	120	0.9	1500	—	—	54	1750

Each type is electrically and mechanically interchangeable with earlier versions of the same basic type. Developed under Navy sponsorship.

Bulb temperature ratings to 265°C.

†Type number for improved CK5704 not assigned.

*15g, 40 cps, fixed frequency
**15g, 30 to 1000 cps sweep

RAYTHEON®

INDUSTRIAL TUBE DIVISION

RELIABLE MINIATURE AND SUBMINIATURE TUBES · VOLTAGE REFERENCE TUBES
VOLTAGE REGULATOR TUBES · PENCIL TUBES · NUCLEONIC TUBES

NEWTON, MASS.: 55 Chapel St. • Bigelow 4-7500
NEW YORK: 589 Fifth Ave. • PLaza 9-3900
CHICAGO: 9501 Grand Ave., Franklin Park • TUxedo 9-5400
LOS ANGELES: 5236 Santa Monica Blvd. • NOrmandy 5-4221